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November 7, 2011

Via Electronic Filing

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: WT Docket Nos. 96-86 and 06-150 and PS Docket No. 06-229
Notice of *Ex Parte* Presentation

Dear Ms. Dortch:

On November 3, 2011, Andrew Rein of Access Spectrum, LLC, Kathleen Wallman of Wallman Consulting, LLC (an advisor to Xanadoo Company), Paul Nagle of Capitol Decisions, Inc., Paul Kolodzy of Kolodzy Consulting, and I met with the following members of the Commission staff: Amy Levine, Office of the Chairman; John Leibovitz, Robert Alderfer, and Tom Peters of the Wireless Telecommunications Bureau; Jennifer Manner, Erika Olsen, and Gene Fullano of the Public Safety and Homeland Security Bureau; and Julius Knapp, Michael Ha, and Walter Johnston of the Office of Engineering and Technology.

During the meeting, we discussed a legislative proposal to combine the Upper 700 MHz A Block and Upper 700 MHz D Block spectrum as part of any legislation that would reallocate the D Block to public safety services. The public interest benefits of including the A Block in any such legislation are set forth in detail in the attached paper and band plan charts, copies of which were distributed to Commission staff. In particular, combining the A Block with the D/Public Safety Broadband Blocks would provide public safety significantly more spectral capacity, which in turn would:
a) increase the amount of spectrum public safety can lease, and/or b) reduce the amount of public funds needed to deploy and operate the public safety network. The representatives of Access Spectrum and Xanadoo Company also discussed how the proposal, if passed by Congress, could be implemented in a way that is consistent with the Commission's technical rules as well as the goal of promoting public safety interoperability.

Pursuant to section 1.1206(b) of the Commission's rules, this letter and the attachments are being submitted for inclusion in the public record in the above-referenced proceedings.

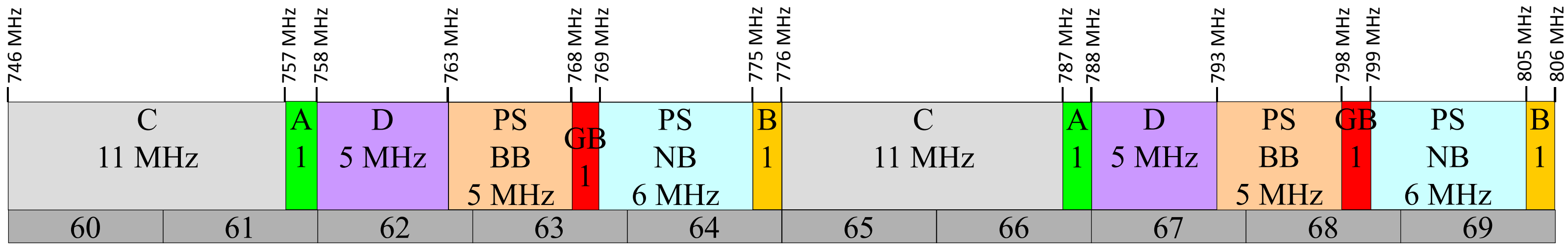
Sincerely,

/s/ *Charles W. Logan*
Charles W. Logan
Counsel to Access Spectrum

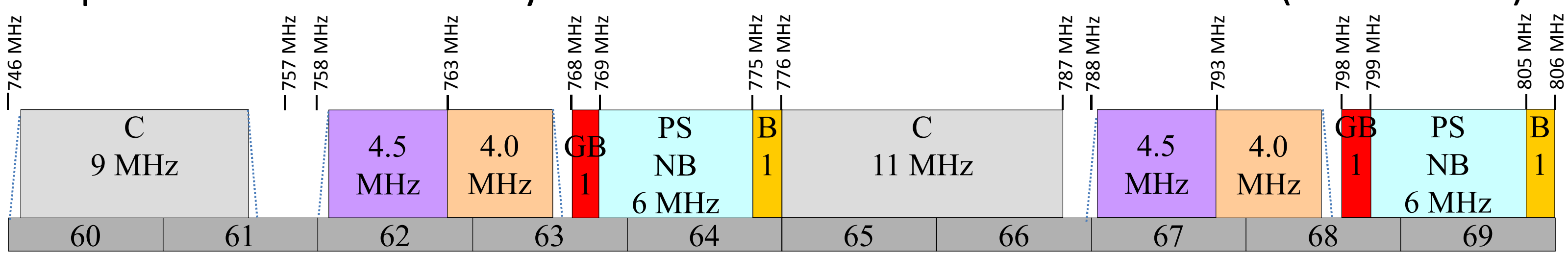
Attachments

cc: Amy Levine
John Leibovitz
Robert Alderfer
Tom Peters
Jennifer Manner
Erika Olsen
Gene Fullano
Julius Knapp
Michael Ha
Walter Johnston

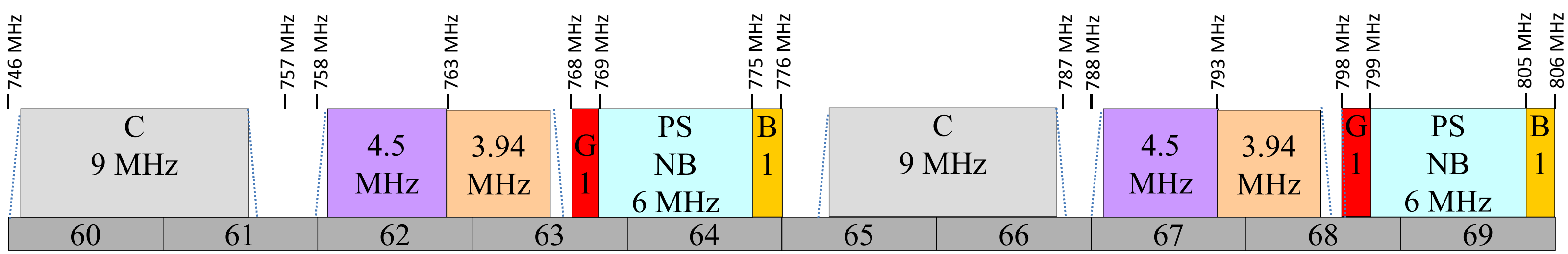
Current Band Plan



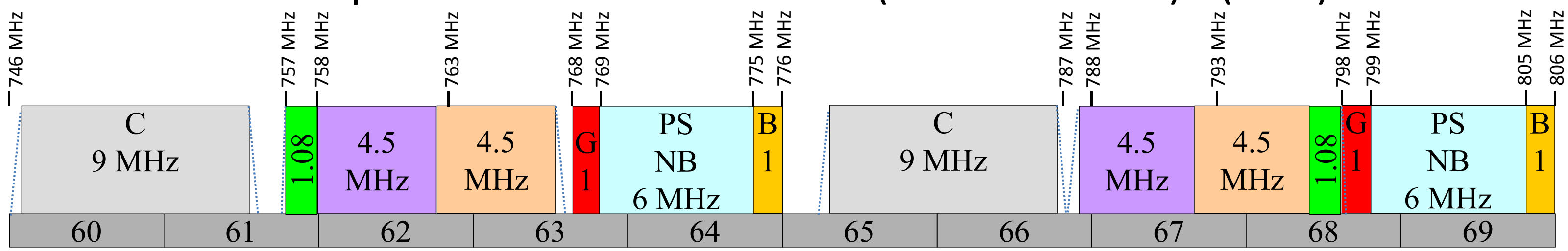
Implementation Necessary to Provide 2 MHz Protection to PS NB (baseline - 1)



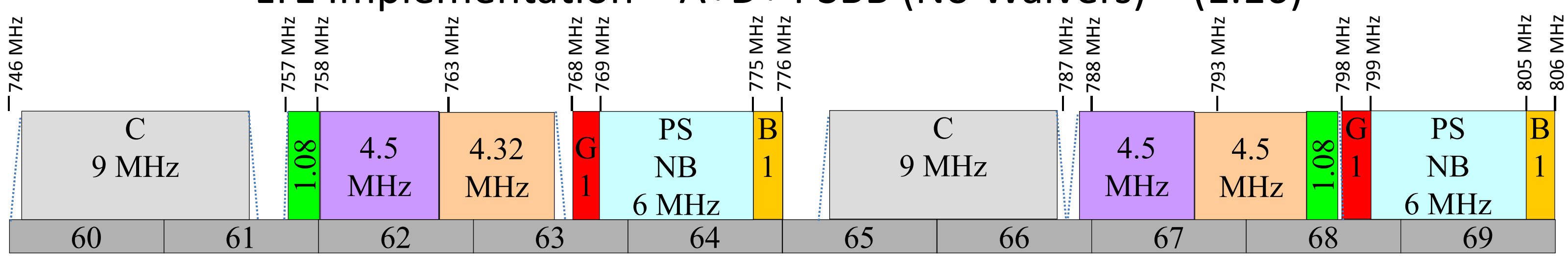
LTE Implementation Necessary (min 180 kHz Resource Blocks) – (.99)



LTE Implementation – A+D+ PSBB (Minor Waivers) - (1.19)



LTE Implementation – A+D+ PSBB (No Waivers) – (1.16)



EMPLOYING THE UPPER 700 MHZ A BLOCK TO REDUCE CONSTRUCTION AND OPERATING COSTS FOR THE PUBLIC SAFETY BROADBAND NETWORK

By

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September 23, 2011

Acknowledgments: This research was sponsored by Access Spectrum and Xanadoo. We would like to thank Jenna Yang, Annie Valkova and Giulia McHenry for their invaluable help in preparing this paper. All errors remain ours.

Disclaimer: The views expressed in this paper are strictly those of the authors and do not necessarily state or reflect the views of The Brattle Group, Inc., Kolodzy Consulting, LLC, or their clients.

I. Introduction

The National Broadband Plan (NBP) recommended the creation of a nationwide interoperable Public Safety broadband network to meet Public Safety's wireless needs over the coming decades.[1] Several draft bills seek to implement that recommendation by adding the 10 MHz Upper 700 MHz D Block ("D Block") to Public Safety's existing 10 MHz Public Safety Broadband Block (collectively referred to herein as "Public Safety Broadband Spectrum" (PSB)). Combining this expanded PSB Spectrum with the Upper 700 MHz A Block ("A Block") would generate configuration efficiencies producing savings of up to $2.5 billion in capital and operating expenditures over 10 years and up to $4 billion over 30 years.[2] Specifically, our analysis shows that assigning the 2 MHz A Block spectrum to Public Safety increases the PSB by 10 percent, but results in a 19 percent increase in its operable spectrum. This, in turn, results in substantial economic and social welfare benefits, including:

- Estimated cost savings between $804 million and $1.0 billion in building the Public Safety broadband network;
- Estimated cost savings of an additional $1.2 billion to $1.5 billion in operating the Public Safety broadband network for the next 10 years;
- Additional potential cost savings of between $1.2 billion and $1.5 billion if the network is operated for 30 years.

If the D Block is reallocated to Public Safety, the simultaneous reallocation of the A Block to Public Safety would effectively reallocate spectrum to its highest valued use.

This paper explains these benefits in detail below. Section II provides background on the 700 MHz Band, including the A Block, D Block, and Public Safety blocks. Section III describes how reallocating the A Block to Public Safety would increase Public Safety's *operable* spectrum by 19 percent with just a 10 percent increase in spectrum. Section IV explains how these configuration efficiencies considerably reduce public safety network construction and operating costs. Finally Section V elaborates on the added benefits that might be enjoyed by Public Safety, including reduced handset costs.

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1 The NBP concluded that Public Safety would realize significant network construction and operation benefits from participation in incentive-based public-private partnerships. The NBP also recommended licensing the D Block for commercial use. See FCC, "Connecting America: The National Broadband Plan," at pp. 313-316 (rel. March 16, 2010), available at: http://download.broadband.gov/plan/national-broadband-plan.pdf ("National Broadband Plan" or "NBP"). This paper is not intended to take a position on the merits of licensing the D Block for commercial use, but rather seeks to illustrate how to optimize use of the D Block if it is reallocated to Public Safety use.

2 We estimated that including the D Block along with the Public Safety block saves close to $7.7 billion in capital expenditures (CapEx) and an additional $11.5 billion in operating expenditures (OpEx) over 10 years. See footnote 15 for further details of these calculations.

II. Background

The current Upper 700 MHz band plan contains a 2 x 11 MHz C Block (assigned to Verizon Wireless), a 2 x 1 MHz A Block (assigned primarily to Xanadoo and Access Spectrum), a 2 x 5 MHz D Block (unassigned), a 2 x 5 MHz Public Safety broadband block, a 2 x 1 MHz Public Safety internal guard band, a 2 x 6 MHz Public Safety narrowband block, and a 2 x 1 MHz B Block (unassigned). These are shown graphically below in Figure 1. (For comparison, Figure 2 shows the more efficient band configuration proposed by this paper assuming the D Block is reallocated to Public Safety use. This will be discussed in more detail in the next section.)

Figure 1: Current Upper 700 MHz Band Configuration

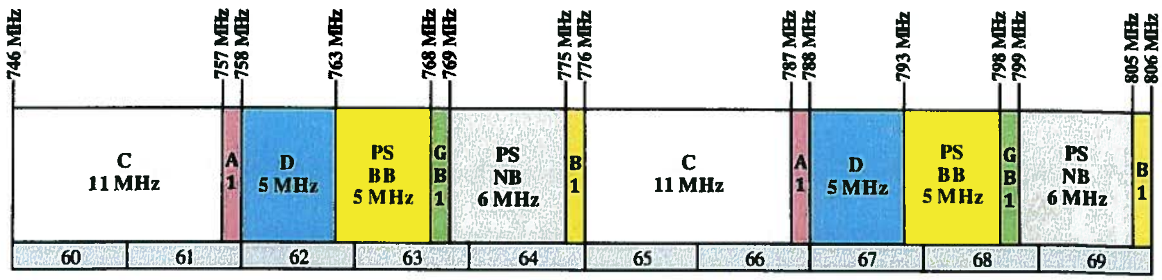
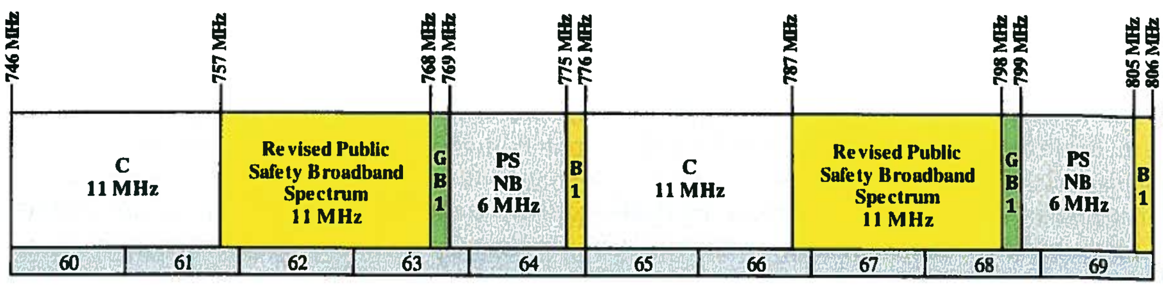


Figure 2: Potential Upper 700 MHz Band Configuration



The 700 MHz radio transmission signals propagate further, and penetrate buildings and other obstacles more effectively than transmissions in higher-frequency spectrum bands. Because of these features, a 700 MHz network will require fewer cell towers than an equivalent network constructed in a higher spectrum band, reducing network construction and operating costs. In 2007, the FCC reorganized the Public Safety 700 MHz allocation to consolidate Public Safety narrowband frequencies and create a 2 x 5 MHz block for Public Safety broadband use.[3] At the same time, the 2 x 5 MHz D Block was designated for auction, but included public/private

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[3] For additional details of this allocation, see the FCC webpage on the 700 MHz Public Safety Band at http://transition.fcc.gov/pshs/public-safety-spectrum/700-MHz/safetyband.html (last visited August 26, 2011).

partnership license conditions, including a requirement to grant Public Safety priority access to the commercial spectrum during times of emergency. Competitive bids for the D Block did not materialize in the FCC auction, and the spectrum remains unassigned.

The A Block spectrum was assigned by auction in 2000 and was relocated to its current position in 2007 when the FCC reconfigured the Upper 700 MHz band. Since the 2 x 1 MHz Upper 700 MHz A Block is held primarily by only two entities (Access Spectrum and Xanadoo) and is not widely encumbered by existing users, the licenses could be reallocated on a nationwide basis with relative ease.[4]

In 2010, the NBP concluded that the United States must have a nationwide broadband network which allows Public Safety first-responders to communicate with one another.[5] In order to use the spectrum for interoperable communication, however, Public Safety needs a nationwide network of wireless broadband transmission towers. The FCC's comprehensive cost model estimates that a stand-alone public safety network deploying the 10 MHz of Public Safety spectrum illustrated in Figure 1 would cost $15.7 billion to construct and an additional 1.5 times that amount to operate for 10 years.[6]

III. Spectral Efficiencies of Combining the A Block with Public Safety Broadband Spectrum

The manner in which spectrum is licensed can affect the spectral efficiencies in the band. The current LTE standards allow for deployment of LTE in configurations of 1.4 MHz, 3 MHz, 5 MHz and larger bandwidths. Normally, if the full configuration is not usable (*i.e.*, a 4 MHz swath of bandwidth can only be configured for a 3 MHz deployment), then a licensee must deploy an internal buffer to meet out-of-band emission ("OOBE") limits. This would subsequently require its LTE equipment vendor(s) to make minor modifications within the LTE standard specific to that band.[7] Spectrum that otherwise could be usable, but instead is set aside as a buffer because of LTE configurations not matching the allocation bandwidth, imposes a quantifiable economic cost that can be minimized with efficient spectrum management. In particular, by assigning the A Block to Public Safety, the spectral efficiencies of the 700 MHz band could be further optimized to benefit Public Safety by requiring less spectrum set aside to

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4 If the A Block is not allocated as a nationwide block to Public Safety, there are a variety of national and regional potential uses for this spectrum, including control channel applications, electric utility smart grid applications, and vehicle fleet management. If, however, the D Block is reallocated to Public Safety use, the A Block represents a unique opportunity to add capacity to a Public Safety broadband network as long as the A Block remains available on a nationwide basis. A Block licensees would need to be compensated if the A Block is reallocated for Public Safety use.

5 *See* NBP at p. 314.

6 Federal Communications Commission, Omnibus Broadband Initiative, "A Broadband Network Cost Model: A Basis for Public Funding Essential to Bringing Nationwide Interoperable Communications to America's First Responders," 2010, pp. 9-10 ("FCC Public Safety Network Cost Model").

7 Each implementation of LTE is specific to the band in which it is deployed to address unique characteristics in the band. For example, LTE Band 13 uses a Network Signaling feature in which the mobile uplink transmissions are modified when operating within a region where public safety is deployed in frequencies close to the Band 13 uplink frequencies.

buffers, as described below. The reconfigured Public Safety allocation that could achieve these efficiencies is illustrated in Figure 2.

The PSB Spectrum, as proposed in some draft legislation, is a 2 x 10 MHz block located between the A Block and the internal guard band of the Public Safety narrowband spectrum. See Figure 1 for reference. It is generally assumed that the PSB Spectrum could utilize a standard 10 MHz LTE channel for its 2 x 10 MHz spectrum blocks. Pursuant to LTE standards, 9 MHz of the 2 x 10 MHz blocks would be usable spectrum. However, due to the potential for interference to Public Safety narrowband operations, an additional 500 kHz of buffer spectrum between the Public Safety broadband and narrowband allocation is likely to be required. Accordingly, this analysis assumes that the Public Safety broadband allocation would be able to use 8.5 MHz in each of the 10 MHz blocks (or 17 MHz of usable spectrum out of the total 20 MHz broadband allocation) as currently contemplated in existing legislation.[8]

Alternatively, combining the A Block with the PSB Spectrum would provide Public Safety with a total broadband allocation of 22 MHz, 20.16 MHz of which would be usable (the remainder being used for internal buffers). Including the A Block in Public Safety's spectrum assignment would result in 2 x 11 MHz blocks. Given the configuration requirements of 10 MHz and 1.4 MHz LTE channels, each 11 MHz could house a full 10 MHz and a 1.4 MHz LTE channel. This configuration also would provide enough internal buffer to protect public safety narrowband operations at 769-775/799-805 MHz. This extra capacity is obtained because a commonly controlled 1.4 MHz LTE carrier (with 1.08 MHz of usable spectrum) and a 10 MHz LTE carrier (with 9 MHz of usable spectrum) may be deployed without spacing between the two carriers.[9]

Critically, the addition of the A Block to the Public Safety spectrum allocation would provide more spectral capacity than the actual amount of spectrum contributed. An additional 10 percent of spectrum would increase total spectrum capacity by approximately 19 percent by enabling additional radio channels. Put another way, Public Safety would gain an additional 3.16 MHz (2 x 1.58 MHz) of *usable* spectrum by adding just 2 MHz of licensed spectrum to its allocation. As explained below, the spectral efficiency gains allow for a network with a less dense tower grid, thereby reducing capital expenditures (CapEx) and operating expenditures (OpEx) for a nationwide Public Safety broadband network. See Figure 3 below for an illustrative example of the benefits of adding the A Block to the PSB. The circled towers represent towers that would

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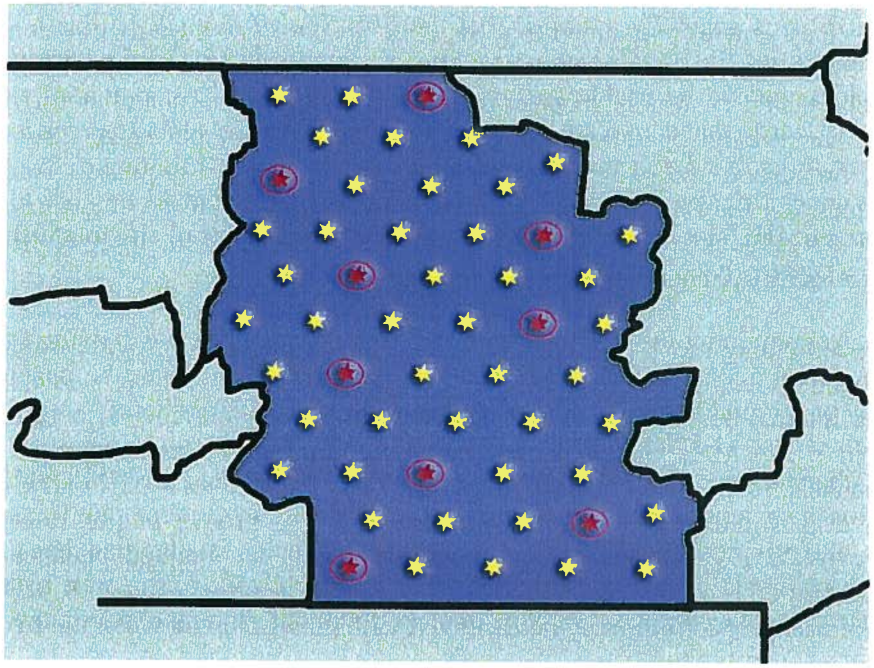
8 Operations that might take place in close proximity to Public Safety Broadband Spectrum base stations may need another 500 kHz of guard band to avoid interference. This is commonly referred to the "Near-Far" problem. Verizon Wireless confronted the same problem with Band Class 13 C Block 11 MHz allocation. It responded by shifting its usage to a 10 MHz block with an additional 1 MHz separation (on top of the 500 kHz separation required by LTE standards) that, when combined with the additional 1 MHz B Block, provided 2.5 MHz of separation from the Public Safety narrowband operations. Verizon Wireless did not take advantage of all the same configuration as the PSB will allow for two reasons: (1) the mobile transmit had much more egregious issues with public safety narrowband; and (2) such an implementation requires two chipsets to exploit, which would have likely been very expensive and complex to warrant the extra capacity.

9 See Appendix B for further explanation of why the addition of the A Block would provide Public Safety with usable spectrum in excess of the A Block's 1 MHz paired.

not have to be built if the A Block was added to the PSB while retaining the same level of network coverage and capacity.[10]

Figure 3: Cell Towers Saved by Including A Block, Worcester MA (Illustrative)



IV. Reduced Network Costs from Combining the A Block with Public Safety Broadband Spectrum

The 19 percent increase in operable spectrum results in a proportional increase in the capacity of each cell tower in the Public Safety Wireless Broadband Network. This incremental increase translates into a considerable reduction in the number of base stations needed for a nationwide network and a correspondingly sizeable reduction in operating expenditures over the next 10 years. Applying the same assumptions used by the FCC to estimate the cost of a stand-alone public safety network, our analyses indicate that the added capacity from the A Block saves between $804 million and $1.0 billion in CapEx, and an additional $1.2 billion to $1.5 billion in OpEx over the next 10 years. This implies possibly as much as $2.4 billion to $3.0 billion in OpEx savings over the next 30 years.[11]

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10 The layout of towers in Figure 3 is purely illustrative. Actual network deployments would be influenced by population distribution, terrain, and location of existing towers. Similarly, the location of the remaining reduced number of sites when the A Block is added to the PSB would likely change.

11 We estimate that the present value of OpEx over 30 years is a little more than 3 times CapEx. The FCC Public Safety Cost Model only considers the present value of operating costs for the first 10 years. As referenced above, the FCC estimates operating costs for 10 years to be at least 150 percent of capital expenditure. In order to determine the operating costs over 30 years, we estimated the likely operating

A. Construction Costs

By combining the A Block with the PSB Spectrum, the public safety network can be constructed with fewer tower sites and, hence, at lower cost. The financial benefits are quantifiable. Our model used the following inputs and assumptions in quantifying the financial benefits of combining the A Block with the PSB. Wherever possible, our model uses the original assumptions from the FCC Public Safety Network Cost Model for estimating the cost savings of including the A Block. Since the FCC Model originally estimated the build-out cost for deploying the Public Safety Block only, in order to estimate the savings from including the A Block, we first estimated the updated build-out requirements for the entire PSB.[12]

1. Coverage and Capacity Considerations

Networks are constructed with the dual goals of capacity and coverage. A "coverage build" focuses on using the minimum number of cell sites to extend signals over the largest possible land area. By contrast, a "capacity build" seeks to achieve a minimum threshold amount of capacity for every system user. A coverage build is suitable for sparsely-populated rural areas, whereas a capacity build is more appropriate for more populated urban and suburban areas. The increase in capacity from adding the A Block to the PSB reduces the number of sites necessary for both coverage and capacity builds.

Additional spectrum can provide coverage benefits by permitting an increase in EIRP (effective isotropically radiated power) for the downlink, which allows for a larger signal footprint. The increase in the signal's footprint is directly proportional to the amount of additional power and the MHz of spectrum deployed for build-out. This benefit, which affects the coverage-build portion of the deployment, extends a site's coverage area proportionally with the amount of additional spectrum deployed. Ultimately this results in the need for fewer sites. Assuming that, like most wireless broadband networks, the network is not capacity constrained for uplink (*i.e.*, the limiting constraint is the amount of data being downloaded to handheld devices), increasing the allocated spectrum by as much as 10 percent could increase the coverage area of a cell by approximately 6 percent.[13]

Additional spectrum also can provide capacity benefits. Generally speaking, network capacity can be increased in one of two ways: the first way is through cell splitting and sectorization to reduce the size of cell radii and increase network capacity within the geographic area of the

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expenditure per year associated with 150 percent of operating costs for 10 years. In particular, assuming operating costs grow by 3 percent per year and the discount rate is 8 percent per year, the first year operating expenditure must be 18.4 percent of revenues. Using these same rates and forecasting the model out 30 years, we estimate that the present value of operating expenditure over 30 years is 301.5 percent.

12 These calculations are discussed in further detail below.

13 For example, if the allocated spectrum block increases by 10 percent, the coverage area of coverage cells for that spectrum block now increases by a factor of 1.10^(2/3.4), or approximately 6 percent, where 3.4 represents the additional attenuations associated with the increase in propagation.

smaller cells. This approach requires an increase in the number of cell towers (base stations). The second way to increase network capacity is to add spectrum. An increase in the bandwidth of usable spectrum transmitted at a given tower results in a proportional increase in the capacity of that tower. This implies that a 19 percent increase in operable spectrum results in a 19 percent increase in cell capacity. The additional spectrum reduces the amount of cell splitting or sectorization needed to accommodate a particular capacity goal. Put simply, the availability of more spectrum requires fewer towers to accomplish the same capacity goal.

2. Inputs and Assumptions

Coverage v. Capacity. The FCC's cost model estimates that a nationwide stand-alone Public Safety network deployed on the 2 x 5 MHz of Public Safety Spectrum would require 44,800 tower sites, 80 percent (or 35,840) of which would be new sites.[14] The FCC's cost model did not indicate what percentage of the Public Safety network was designed for coverage and what percent was designed for capacity. Additionally, the FCC estimate is based on a network deployed on the 10 MHz Public Safety Block, rather than the entire 20 MHz PSB currently being considered. Using the FCC's available inputs, we estimate that 82 percent of the network deployed on the Public Safety Block is capacity driven and the remaining 18 percent is coverage driven.[15]

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[14] See FCC Public Safety Network Cost Model, p. 9 and n. 13. We also assume the Public Safety Block alone would be configured as 2 x 5 MHz channels with 2 x 4 MHz of usable spectrum.

[15] As of the 2010 Census, the current U.S. population is nearly 308,745,538 people. The PSB network is expected to cover 95 percent of this population. Assuming the network is intended to cover the counties with the largest populations, this implies the network will cover the most populated 1,708 counties. Assuming that the cell radius of a coverage site is 7.2 miles for a build-out using only the Public Safety Block spectrum, the coverage area of a coverage site is 135 square miles (where coverage area is calculated as a hexagon with sides equal to the cell radius). Assuming 135 square mile coverage sites, it would require 13,158 cells to cover the most populated 1,708 counties. The remaining cells would be additional sites required in order to meet capacity demands. Furthermore, not all of the initial 13,158 sites would actually be coverage sites. For any county with additional capacity sites, we assume that for each capacity site, at least one coverage site is less than its maximum size, thus reclassifying it as a capacity site. Thus, only 7,851 sites (18 percent) are likely to be coverage sites of 135 square miles. The remaining 36,949 sites (82 percent) are capacity sites. Based on these assumptions, each capacity site covers a maximum population of 7,218 pops.

Furthermore, based on the same approach and our initial calculations our Greenfield model implies that, for the entire 2 x 10 MHz PSB build-out including the D Block, there are 22,808 cells required, 72 percent of which would be capacity driven, while the remaining 28 percent would be coverage driven. Adding the D Block to the existing Public Safety Block would effectively double Public Safety's deployed spectrum from 10 MHz to 20 MHz. As a result, the average coverage cell area would increase by 50 percent to 202 square miles. (For a 100 percent increase in deployable spectrum, coverage increases by (1+100%)^2/3.4 = 50%). Assuming 202 square miles per cell, it would require 9,036 cells to cover the 1,708 most populated counties. In addition, the capacity of each capacity driven site would increase by 113 percent, from 7,218 pops to 15,337 pops per site. By reclassifying coverage sites as capacity sites in densely populated areas, there are only 6,293 sites (28 percent) driven by coverage. Further, there are a total of 16,515 capacity sites. As a result, including the D Block as part of its network saves Public Safety $7.7 billion in capital expenditures and an additional $11.5 billion in operating expenditures.

Consistent with the FCC model, we assume that out of a total of 44,800 sites nationwide, approximately 7 percent (or 3,200) will be rural and the remaining sites will be non-rural, and all rural sites are coverage sites.[16] We assumed that 44 percent of non-rural sites are urban and the remaining non-rural sites, or 56 percent, are suburban. These assumptions are also consistent with the FCC estimate.[17] Assuming 18 percent of cells are coverage cells, approximately 11 percent of cells will be non-rural coverage cells.

Deployment Efficiency. Another factor to consider when contemplating network construction costs is deployment efficiency. An existing tower with corresponding backhaul and power may not exist at the specific location necessary to exploit the potential reduction of the number of sites. A deployment efficiency factor measures how frequently a base station can be located where it is needed for optimal deployment performance. The FCC model assumes that a stand-alone Public Safety network would build 80 percent of the necessary towers, and use existing towers for the remaining 20 percent.[18] Because there is little reliance on the locations of legacy network sites, a new-build status provides greater opportunities for optimal site location and, hence, greater deployment efficiency.

To be conservative, however, we also considered the possibility that there still are some deployment efficiency losses. In this case we assume different deployment efficiency figures for rural and non-rural areas. There are many existing tower sites available in urban and suburban areas that could be utilized whereas there are many fewer available tower sites in rural areas. This is consistent with the assumptions built into the FCC's cost model. In developing the cost benefit model, we utilized 25 percent rural deployment efficiency (meaning that 25 percent of the time, a tower could be located where it needed to be located for optimal performance) and 75 percent non-rural deployment efficiency due to the large number of deployed sites and associated infrastructure.

Tower Site Costs. The FCC estimates that the cost of a tower site varies by its location, with rural sites being the most expensive and urban sites being the least expensive. We used the tower site costs for rural, suburban, and urban areas that were set forth in the FCC's cost model. In addition to the cost of towers, the FCC estimated a series of other costs that should be included in tower costs. These include $35,000 for hardening of non-rural new sites; $50,000 per non-rural cell for backhaul; and $23,000 per cell for IP core equipment and network operations centers.[19] The FCC's model assumes that 80 percent of sites will be new builds, with the remaining 20 percent using existing towers that will be retrofitted with the necessary LTE

16 See FCC Public Safety Network Cost Model, Exh. 3. The FCC states that 3,200 sites are rural.

17 *Op. cit.* Exh. 3. Based on the FCC estimated costs per tower and total cost for urban, suburban new builds and existing tower upgrades, we believe there are approximately 14,600 new urban sites, 18,500 new suburban sites, 3,500 existing urban sites and 4,500 existing suburban sites.

18 *Op. cit*, p. 5.

19 *Op. cit*, App. D. The FCC estimates a total of $1.2 billion for hardening non-rural new sites; $2.1 billion in backhaul for nearly 12,500 non-rural; and $1.0 billion in IP Core Equipment, Network Operation Centers for all 44,800 sites.

channels.[20] Table 1 includes the weighted average costs of towers for rural, suburban and urban builds based on these assumptions.

Table 1: FCC's Estimated Public Safety Tower Cost

	New Build Sites		Existing Build Sites		Weighted Average
Percent of Cells	80%		20%		100%
	Tower Costs	Additional Costs	Tower Costs	Additional Costs	
	[1]	[2]	[3]	[4]	[5]
Rural Site	$394,632	$23,000	$247,232	$23,000	$388,152
Suburban Site	$288,752	$108,000	$213,752	$73,000	$374,752
Urban Site	$223,752	$108,000	$163,752	$73,000	$312,752

Sources and Notes:

[1], [2], [3], and [4]: "A Broadband Network Cost Model," FCC, p. 18, May 2010.

[2]: Includes $1,027,939,000 of IP core equipment and network operation centers costs for all 44,800 sites as well as $35,000 hardening cost per site and $2,078,672,676 of backhaul costs for only non-rural sites (92% of total sites).

[4]: Includes $1,027,939,000 of IP core equipment and network operation centers costs for all 44,800 sites as well as $2,078,672,676 of backhaul costs for only non-rural sites (92% of total sites).

[5]: (80% x ([1]+ [2])) + (20% x ([3]+ [4])).

B. Operating Costs

The Public Safety broadband network will incur ongoing operating costs, such as backhaul, microwave backhaul, managing network operations centers and IP core equipment, etc. The FCC's cost model estimated that the Public Safety network's operating expenses for a 10 year period would equal approximately 1.5 – 2.5 times the network construction costs.[21] Thus, reductions in capital expenditures can be expected to produce a larger reduction in operating expenditures. We used the more conservative estimate that operating expenditures over a ten-year period would equal 1.5 times the capital expenditures.

C. Cost Savings to Using Existing Sites

As discussed above, using existing sites for 20 percent of the build-out will likely imply some losses to efficiency based on existing site locations. With the assumptions listed above, the additional capacity provided by the A Block would permit construction of the nationwide public safety network with approximately 2,309 fewer towers.[22] Fewer towers would lead to significant

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20 See FCC Public Safety Cost Model, App. D. Although it is not explicit, based on the FCC total spending on new and existing rural sites, this 80/20 split appears to apply to rural builds as well.

21 *Op cit.*, p. 12, n. 18 and Exh. 8.

22 Assumptions applied to this analysis include the initial 18 percent coverage and 82 percent capacity distribution of cells; the rural and non-rural deployment efficiencies; the tower site costs from Table 1; and the distributions of rural and non-rural cells from the FCC analysis. See Appendix A for details. The model further assumes that the A Block alone has 8 MHz (2 x 4 MHz) of usable spectrum, including the D

savings. The savings in network construction costs would close to $804 million. The savings in network operating costs would exceed $1.2 billion over ten years. Thus, adding the A Block spectrum to the public safety allocation would **save approximately $2.0 billion** in capital and operating expenditures for a nationwide Public Safety broadband network. See Table 2.

Table 2: Summary of Cost Savings from Modifying Existing Build

[1]	Reduction in New Rural Coverage Sites		*Sites*	23
[2]	Cost Per New Rural Coverage Cell		*$*	417,632
[3]	Reduction in Existing Rural Coverage Sites		*Sites*	8
[4]	Cost Per Existing Rural Coverage Cell		*$*	270,232
[5]	**Total Savings for Rural Coverage Cell**		*$*	**11,767,392**
[6]	Non-Rural Coverage Cells		*Sites*	139
[7]	Non-Rural Capacity Cells		*Sites*	2,139
[8]	Cost Per New Non-Rural Cell		*$*	**347,582**
[9]	**Total Savings for Non-Rural Cells**		*$*	**791,791,486**
[10]	**Total Buildout Cost (Capex) Saved**		*$*	**803,558,878**
[11]	**Total Ongoing Cost (Opex) Saved**	150%	*$*	**1,205,338,318**

Notes:
[1], [3], [6], and [7]: See Appendix A.
[2]: Cost of new rural cell sites (including additional costs). See Table 1.
[4]: Cost of existing rural cell sites (including additional costs). See Table 1.
[5]: ([1] x [2]) + ([3] x [4]).
[8]: Weighted average cost of 44% urban and 56% suburban cell sites from Table 1.
[9]: [8] x ([7]+[6]).
[10]: [9] + [5].
[11]: [10] x 150%.

4. Cost Savings to Greenfield Build Approach

We also estimated the cost savings under an alternative approach: an unconstrained Greenfield build in which towers can be placed in optimal locations. Such an approach should provide an upper bound on savings from adding the A Block to the PSB spectrum allocation. In this case,

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Block adds 9 MHz (2 x 4.5 MHz) of usable spectrum, and including the A Block adds 3.16 MHz (2 x 1.58 MHz) of usable spectrum.

For the calculation of cells required for the Public Safety and D Blocks, the model applies deployment efficiencies exclusively to existing sites. However, for the estimation of cost savings from including the A Block, the model applies the deployment efficiencies to both new and existing sites.

the nearly 19 percent increase in usable spectrum results in a similar increase in the maximum population per cell tower for capacity cells. The coverage area of coverage towers increases by almost 6 percent from 202 square miles to 214 square miles.[23]

Based on these assumptions, including the A Block spectrum in a Greenfield build results in approximately 128 fewer coverage sites and 2,792 fewer capacity sites than would be required for a Public Safety network including the D Block and incorporating legacy sites.[24] Based on Table 1, we assume that the weighted average cost of rural coverage cells is $312,752, and the weighted average cost of non-rural cells is equal to the cost of suburban cells, $374,752. Finally, we assume the weighted average cost of capacity towers is approximately $347,472. The calculations produce a total savings of $1.0 billion in CapEx and another nearly $1.5 billion in OpEx over 10 years. This represents a total of $2.5 billion in cost savings over 10 years. See summary Table 3.

Table 3: Summary of Greenfield Build Cost Savings

[1]	Number of Fewer Rural Coverage Cells Required		***Sites***	51
[2]	Cost Per Rural Coverage Cell		***$***	388,152
[3]	Number of Fewer Non-Rural Coverage Cells Required		***Sites***	77
[4]	Cost Per Non-Rural Coverage Cell		***$***	374,752
[5]	Number of Fewer Capacity Cells Required		***Sites***	2,792
[6]	Cost Per Capacity Cell		***$***	347,472
[7]	**Total Buildout Cost (Capex) Saved**		***$***	1,018,793,480
[8]	**Total Ongoing Cost (Opex) Saved**	150%	***$***	1,528,190,220

Notes:

[1], [3], [5]: Based on The Brattle Group (TBG) analysis.

[2]: Weighted average of new and existing cell sites for rural sites. See Table 1.

[4]: Weighted average of new and existing cell sites for suburban sites. See Table 1.

[6]: Weighted average cost (see Table 1) of 44% urban and 56% suburban cell sites.

[7]: ([1] x [2]) + ([3] x [4]) + ([5] x [6]).

[8]: [7] x 150%.

23 For a 10 percent increase in the allocated spectrum, the coverage increases by (1+10%)^(2/3.4) = 6%.

24 Following the same model discussed for calculating the ratio of coverage to capacity sites (see footnote 14), based on this increased area, it now only requires 8,564 sites to cover the most populated 1,708 counties. Further, each capacity cell now has a maximum population of 18,188. As a result, the build-out requires 13,723 capacity cell sites and approximately 6,165 coverage cell sites. The coverage to capacity ratio for such a build-out is 31 percent coverage and 69 percent capacity.

V. Additional Savings from Combining the A Block with Public Safety Broadband Spectrum

Wider duplex spacing makes it easier to build handset filters. Verizon Wireless has announced that it will shift the 10 MHz of utilized spectrum to the lower frequencies of its lower C Block segment and will shift the 10 MHz of utilized spectrum to the upper frequencies of its upper C Block segment. This spacing reduced the cost of Verizon's handset filters for its recent 4G deployment. Combining the A Block with the Public Safety Broadband Spectrum would allow Public Safety to employ similar duplex spacing and save costs on handset devices. It is difficult to estimate the level of savings per public safety handset that would result from duplex spacing. Given the large number of public safety employees in the United States,[25] however, even a modest per-device savings would produce significant total savings.

VI. Conclusion

If the D Block is reallocated to Public Safety, the new Public Safety Broadband Spectrum could be combined with the A Block to reduce Public Safety network construction and operating costs by approximately $2.5 billion over ten years and an additional $1.2 - $1.5 billion over the next 30 years. In addition to these substantial savings, the addition of the A Block spectrum would translate into lower Public Safety handset costs.

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[25] According to the U.S. Bureau of Labor Statistics there were approximately 1.5 million paid Public Safety employees in 2008. Further, in 2007 70 percent of fire companies were staffed entirely by volunteer fire fighters who would not be included as paid employees, but will also likely require handsets. See Bureau of Labor Statistics, "Occupational Outlook Handbook, 2010-11 Edition," United States Department of Labor, available at: http://www.bls.gov/oco (last visited September 14, 2011).

Appendix A. Summary of Detailed Analysis for Table 2

				Total 100% [A]	New Sites 80% [B]	Existing Sites 20% [C]
[1]	**Total Cell Sites**			44,800		
[2]	Initial Rural Sites (7%)	7%	*Sites*	3,200	2,560	640
[3]	Initial Non-Rural Sites (93%)	93%	*Sites*	41,600	33,280	8,320
[4]	**Cell Sites (18% Coverage and 82% Capacity)**					
[5]	Rural Coverage Sites	7%	*Sites*	3,200	2,560	640
[6]	Non-Rural Coverage Sites (12% of non-rural sites)	11%	*Sites*	4,992	3,994	998
[7]	Capacity Sites (88% of non-rural sites)	82%	*Sites*	36,608	29,286	7,322
	Spectrum Allocated					
[8]	Current PS Block	2 x	*MHz*	5.00	5.00	5.00
[9]	D Block to be allocated	2 x	*MHz*	5.00	5.00	5.00
[10]	A Block to be allocated	2 x	*MHz*	1.00	1.00	1.00
	Usable Spectrum					
[11]	Current PS Block	2 x	*MHz*	4.00	4.00	4.00
[12]	D Block to be allocated	2 x	*MHz*	4.50	4.50	4.50
[13]	A Block to be allocated	2 x	*MHz*	1.58	1.58	1.58
	Efficiency Improvement with D Block					
[14]	Coverage Efficiency Improvement			0.335		
[15]	Overall Rural Coverage Gain				0.335	0.084
[16]	Overall Non-Rural Coverage Gain				0.335	0.251
[17]	Capacity Gain			0.529		
[18]	Overall Capacity Gain				0.529	0.397
	Cell Sites Needed with D Block					
[19]	Rural Coverage Sites	10%	*Sites*	2,289	1,703	586
[20]	Non-Rural Coverage Sites	14%	*Sites*	3,404	2,656	748
[21]	Capacity Sites	76%	*Sites*	18,196	13,782	4,414
	Efficiency Improvement with A Block					
[22]	Coverage Efficiency Improvement			0.055		
[23]	Overall Rural Coverage Gain				0.014	0.014
[24]	Overall Non-Rural Coverage Gain				0.041	0.041
[25]	Capacity Efficiency Improvement			0.157		
[26]	Overall Capacity Gain				0.118	0.118
	Reduction in Cell Sites with A Block					
	Reduction in Coverage Sites					
[27]	Rural Sites	1%	*Sites*	31	23	8
[28]	Non-Rural Sites	6%	*Sites*	139	109	31
	Reduction in Capacity Sites					
[29]	Non-rural Sites	93%	*Sites*	2,139	1,620	519

Appendix A Cont. Summary of Detailed Analysis for Table 2

Notes:

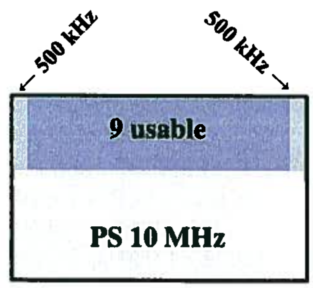
[1], [2], [3]: "A Broadband Network Cost Model," FCC, May 2010.
[4], [5], [6], [7]: Apportions the 44,800 cell sites accordingly.
[8], [9], [10], [11], [12], [13]: Discussed in paper.
[14][A], [15][B], [16][B]: 1 - 1 / (([8] + [9]) / ([9])) ^ (2 / 3.4).
[15][C]: 25% x [14] based on 25% rural deployment efficiency for existing coverage sites.
[16][C]: 75% x [14] based on 75% rural deployment efficiency for existing coverage sites.
[17], [18][B]: [12] / ([12] + [11]).
[18][C]: 75% x [17] based on 75% rural deployment efficiency for existing capacity sites.
[19][A]: [19][B] + [19][C]. [19][B]: [5][B] x (1 - [15][B]). [19][C]: [5][C] x (1 - [15][C]).
[20][A]: [20][B] + [20][C]. [20][B]: [6][B] x (1 - [16][B]). [20][C]: [6][C] x (1 - [16][C]).
[21][A]: [21][B] + [21][C]. [21][B]: [7][B] x (1 - [18][B]). [21][C]: [7][C] x (1 - [18][C]).
[22]: 1 - 1 / (([8] + [9] + [10]) / ([8]+[9])) ^ (2 / 3.4).
[23][B], [23][C]: 25% x [22] based on 25% rural deployment efficiency for existing and new coverage sites.
[24][B], [24][C]: 75% x [23] based on 75% rural deployment efficiency for existing and new coverage sites.
[25]: [13] / ([11] + [12] + [13]).
[26][B], [26][C]: 75% x [25] based on 75% rural deployment efficiency for existing and new capacity sites.
[27][A]: [27][B] + [27][C]. [27][B]: [19][B] x [23][B]. [27][C]: [19][C] x [23][C].
[28][A]: [28][B] + [28][C]. [28][B]: [20][B] x [24][B]. [28][C]: [20][C] x [24][C].
[29][A]: [29][B] + [29][C]. [29][B]: [21][B] x [26][B]. [29][C]: [21][C] x [26][C].

Appendix B

The amount of usable spectrum is affected by four factors: (1) the block size; (2) the 3GPP LTE standard channel width (1.4 MHz, 3 MHz, 5 MHz and 10 MHz building blocks); (3) the internal buffer required by the LTE standard for the particular channel width; and (4) the proximity to Public Safety narrowband operations.

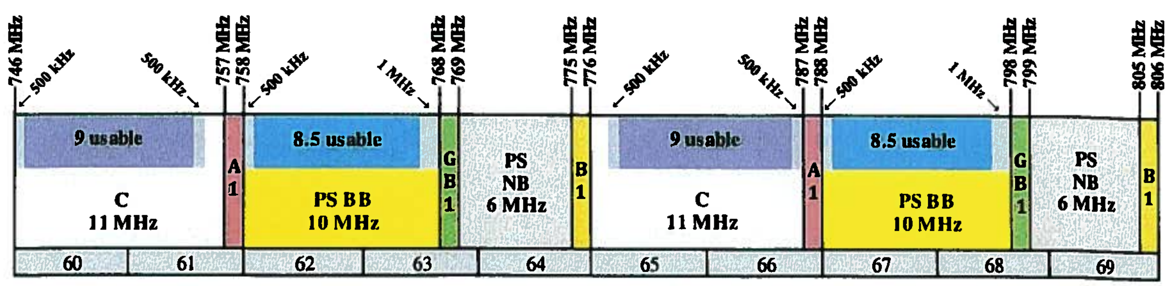
A 10 MHz block normally would accommodate a full 10 MHz LTE channel. This would involve 500 kHz of buffer at each end of the LTE band and 9 MHz of usable spectrum, as illustrated below.

Appendix B1: Standard 10 MHz block



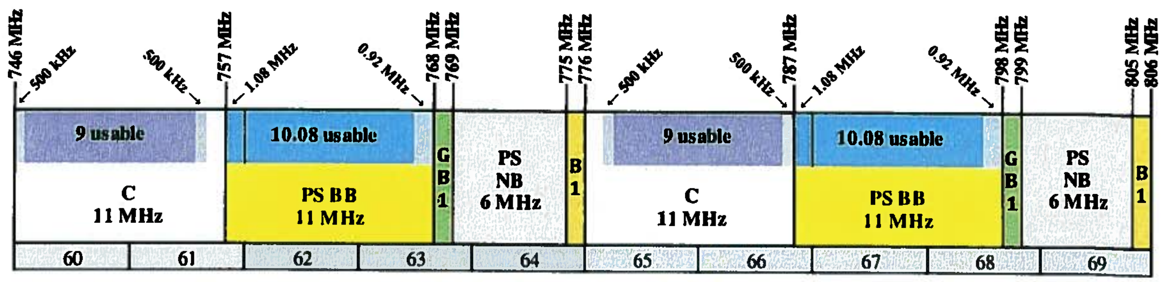
Where it is located within the 700 MHz band, however, the 10 MHz block of Public Safety Broadband Spectrum would be unable to house the full amount of usable spectrum that would normally be available in a full 10 MHz LTE channel. The 2 x 10 MHz blocks could each accommodate a 10 MHz LTE channel width that includes 500 kHz buffers at either end of the band (leaving 9 MHz of usable spectrum). However, up to 2 MHz of spacing is required from Public Safety narrowband operations. Thus, even with the 1 MHz internal Public Safety guard band and the 500 kHz buffer required by LTE standards, the Public Safety broadband allocation would have to include an additional 500 kHz internal buffer at the upper edge. Accordingly, without the A Block, the 10 MHz (paired) Public Safety broadband allocation would accommodate only 8.5 MHz of usable spectrum.

Appendix B2: Usable Spectrum D + PS BB



With the addition of the A Block, however, the 11 MHz downlink portion of the PSB Spectrum could be deployed as a block of 10.08 MHz of usable spectrum (9 MHz + 1.08 MHz) with 1.92 MHz spacing from the Public Safety Narrowband operations (0.92 MHz of internal buffer + the 1.0 MHz Public Safety internal guard band). At the lower edge, this configuration would maintain the 3GPP-required 1 MHz of spacing between the PSB Spectrum and the 3GPP band that Verizon Wireless (the C Block licensee) is using within its C Block because Verizon Wireless has deployed its mobile receive band with a 1 MHz internal buffer next to the A Block.[26]

Appendix B3: Usable Spectrum A + D + PS BB



[26] It should be noted that spacing between like downlink services is generally not needed and thus operating in such a configuration should be possible. However, it will not meet the FCC technical rules and thus this needs to be addressed by mutual agreement with the C Block licensee (Verizon Wireless).

Table 1. Public Safety Broadband Corporation Expenditures and Revenues (2012 - 2021)

		Public Safety and D Blocks [A] *$ Millions*	Public Safety, D and A Blocks [B] *$ Millions*
[1]	Capital Expenditure (CapEx) for Build-Out	11,500	11,500
[2]	Interest Payment	250	194
[3]	**Total Build-Out Cost**	**11,750**	**11,694**
[4]	Operating and Administrative Costs	13,853	13,853
[5]	Revenues from Leasing Capacity	12,828	15,266
[6]	Net Operating Income	**-1,025**	**1,412**
[7]	**Net CapEx, Operating and Administrative Costs**	**12,525**	**10,088**
[8]	**Additional Revenue Leasing from A Block**		**2,437**

Sources and Notes:

[A]: The Brattle Group analysis of CBO Cost Estimate, S.911 Public Safety Wireless Innovation Act (July 20, 2011). See attached Table 2.

[B]: The Brattle Group analysis derived from analysis of CBO Cost Estimate. See attached Table 3.

[3]: [1] + [2].

[6]: [5] - [4].

[7]: [1] + [4] - [5].

[B][8]: [A][7] - [B][7].

Table 2. CBO Estimation of Public Safety Broadband Expenditures and Revenues

CBO Assumptions		
Sites to Cover 95% of Population (by 2018):	*Sites*	45,000
Average Cost to Public Safety per Site:	*$*	170,000
Remaining 4% of Build-Out:	*Sites*	3,000
Average Cost per Site for Remaining 4% of Build-Out:	*$*	340,000

Additional Brattle Assumptions		
Interest Rate on Borrowing:		1.46%
Annual OpEx as a Multiple of Cumulative CapEx:		18%
Net Operating Income in Year 1:	*$ Millions*	-227
Estimated Number of Public Safety Subscribers by 2021:		1,500,000
Annual Administrative Cost per Public Safety Subscriber:	*$*	100
Total Administrative Cost for Public Safety:	*$ Millions*	150

Year	No. Towers per Year	Cost per Tower	Total Tower Costs	Fixed Costs (Implied)	Capital Expenditure	Operating Cost	Capacity Built	Percent of Capacity Leased	PS Admin Cost	PS + D Total Lease Revenue	Net Operating Income	CBO S.911 Outlays	Annual Borrowing	Recurring Loan	Interest Payment	Total Build-Out Cost
			$ Millions	*$ Millions*	*$ Millions*	*$ Millions*			*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
2012	6,429	$ 170,000	1,093	357	1,450	-	13%	0%	0	-	-	25	1,425	-	-	1,450
2013	6,429	$ 170,000	1,093	357	1,450	522	27%	12%	18	313	(227)	150	1,527	1,425	21	1,470
2014	6,429	$ 170,000	1,093	357	1,450	783	40%	20%	30	521	(291)	950	791	2,951	43	1,493
2015	6,429	$ 170,000	1,093	357	1,450	1,044	54%	30%	45	782	(307)	2,450	(694)	3,742	54	1,504
2016	6,429	$ 170,000	1,093	357	1,450	1,305	67%	35%	53	913	(445)	2,550	(656)	3,049	44	1,494
2017	6,429	$ 170,000	1,093	357	1,450	1,566	80%	55%	83	1,434	(214)	2,500	(836)	2,393	35	1,484
2018	6,426	$ 170,000	1,092	357	1,449	1,826	94%	70%	105	1,825	(106)	2,100	(545)	1,557	23	1,472
2019	1,425	$ 340,000	485	158	643	1,942	97%	80%	120	2,086	24	1,050	(431)	1,012	15	657
2020	1,425	$ 340,000	485	158	643	2,058	100%	90%	135	2,347	154	600	(111)	581	8	651
2021	150	$ 340,000	51	17	68	2,070	100%	100%	150	2,607	387	150	(470)	470	7	74
2012 - 2016	**32,145**		**5,465**	**1,784**	**7,248**	**3,653**			**146**	**2,529**	**(1,270)**	**6,125**	**2,393**			**7,411**
2012 - 2018	**45,000**		**7,650**	**2,497**	**10,147**	**7,045**			**333**	**5,788**	**(1,590)**	**10,725**	**1,012**			**10,367**
2012 - 2021	**48,000**		**8,670**	**2,830**	**11,500**	**13,115**			**738**	**12,828**	**(1,025)**	**12,525**	**(0)**		250	**11,750**
Percent of CapEx			***75%***	***25%***		***114%***										
CBO Estimates (2012 - 2021)					**$ 11,500**						**(1,000)**	**12,525**			**250**	**11,750**

Table 2. CBO Estimation of Public Safety Broadband Expenditures and Revenues

Notes and Sources:
[1] - [2]: Brattle assumptions based on CBO Cost Estimate for S. 911 in which 45,000 towers are built by 2018 at a cost of $170,000 per tower, and another 3,000 highly rural cells are built by 2021 at twice that cost (see CBO Score, pp. 7 - 8).
[3]: [1] * [2] / 1,000,000.
[4] & [5]: According to the S.911 Score, $11500 million is spent on capital expenditure. Given that tower costs total $8670 million, fixed costs must make up the remaining $2830 million. This represents 25% of capital expenditure.
[6]: 18% * cumulative([5]); based on The Brattle Group analysis of the FCC Cost Model, operating costs are equal to 18% of cumulative capital expenditure.
[7]: Cumulative([1]) / sum([1]).
[8]: The Brattle Group assumption to achieve a total net income of approximately -$1000 million for the period 2012 - 2021.
[9]: [8] * $100 per Public Safety subscriber * 1.7 million Public Safety subscribers. According to the BLS there were approximately 1.5 million employed firefighters (excludes volunteers), EMT and paramedics and police officers in the U.S. in 2008. By 2018, there are projected to be over 1.6 million employed Public Safety personnel, which implies a 1.08% annual increase in personnel. Projecting this annual increase out three more years, by 2021 there should be 1.7 million Public Safety employees."
[10]: Lease revenue in 2012 assumed to still be $0; lease revenue in 2013 calculated to achieve approximately -$200 million in net operating income; lease revenue for all subsequent years based on percent increase in leasable capacity in column [8].
[11]: [10] - [6] - [9].
[12]: See S.911 Score, pp. 2 - 3.
[13]: [5] - [11] - [12].
[14]: Cumulative([13]) through previous year.
[15]: [14] * 1%; Where interest rate chosen to achieve $250 million in total interest payments based on S.911 Scoring in which the difference between total build-out cost ($11750 million and total capital expenditure $11500 million is $250 million in interest payments.
[16]: [5] + [15].

Table 3. TBG Analysis of Public Safety Broadband Expenditures and Revenues Including A Block Spectrum

CBO Assumptions		
Sites to cover 95% of pop (by 2018):	*Sites*	45,000
Average Cost to Public Safety per Site:	*$*	170,000
Remaining ~4% of build-out:	*Sites*	3,000
Average Cost per Site for Remaining ~4% of build-out:	*$*	340,000

Additional Brattle Assumptions		
Interest rate on borrowing:		1.46%
Annual Opex as a multiple of cumulative Capex:		18%
Net operating income in Year 1:	*$ Millions*	-227
Number of Public Safety Subscribers:		1,500,000
Annual Administrative Cost per Public Safety Subscriber:	*$*	100
Total Administrative Cost for Public Safety:	*$ Millions*	150
Capacity Increase from including A block:		19%

Year	No. Towers per Year	Cost per Tower	Total Tower Costs	Fixed Costs (Implied)	Capital Expenditure	Operating Cost	Capacity Built	Percent of Capacity Leased	PS Admin Cost	PS + D Total Lease Revenue	PS + D + A Total Lease Revenue	Net Operating Income	CBO S.911 Outlays	Annual Borrowing	Recurring Loan	Interest Payment	Total Build-out cost
			$ Millions	*$ Millions*	*$ Millions*	*$ Millions*			*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*Millions*	*$ Millions*	*$ Millions*	*$ Millions*	*$ Millions*
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
2012	6,429	$ 170,000	1,093	357	1,450	-	13%	0%	0	-	-	-	25	1,425	-	-	1,450
2013	6,429	$ 170,000	1,093	357	1,450	522	27%	12%	18	313	372	(168)	150	1,467	1,425	21	1,470
2014	6,429	$ 170,000	1,093	357	1,450	783	40%	20%	30	521	621	(192)	950	692	2,892	42	1,492
2015	6,429	$ 170,000	1,093	357	1,450	1,044	54%	30%	45	782	931	(158)	2,450	(842)	3,584	52	1,502
2016	6,429	$ 170,000	1,093	357	1,450	1,305	67%	35%	53	913	1,086	(271)	2,550	(829)	2,741	40	1,490
2017	6,429	$ 170,000	1,093	357	1,450	1,566	80%	55%	83	1,434	1,707	58	2,500	(1,109)	1,912	28	1,478
2018	6,426	$ 170,000	1,092	357	1,449	1,826	94%	70%	105	1,825	2,172	240	2,100	(804)	804	12	1,461
2019	1,425	$ 340,000	485	158	643	1,942	97%	80%	120	2,086	2,482	420	1,050	-	-	-	643
2020	1,425	$ 340,000	485	158	643	2,058	100%	90%	135	2,347	2,792	600	600	-	-	-	643
2021	150	$ 340,000	51	17	68	2,070	100%	100%	150	2,607	3,103	883	150	-	-	-	68
2012 - 2016	**32,145**		**5,465**	**1,784**	**7,248**	**3,653**			**146**	**2,529**	**3,010**	**(789)**	**6,125**	**1,912**			**7,403**
2012 - 2018	**45,000**		**7,650**	**2,497**	**10,147**	**7,045**			**333**	**5,788**	**6,888**	**(490)**	**10,725**	**-**			**10,341**
2012 - 2021	**48,000**		**8,670**	**2,830**	**11,500**	**13,115**			**738**	**12,828**	**15,266**	**1,412**	**12,525**	**-**		**194**	**11,694**
Percent of CapEx			***75%***	***25%***		***114%***											
CBO S.911 Estimates (2012 - 2021)					**$ 11,500**							**$ (1,000)**	**$ 12,525**			**$ 250**	**$ 11,750**

Table 3. TBG Analysis of Public Safety Broadband Expenditures and Revenues Including A Block Spectrum

Notes and Sources:
[1] - [10]: Analysis is identical to previous Table 2.
[1] - [2]: Brattle assumptions based on CBO Cost Estimate for S. 911 in which 45,000 towers are built by 2018 at a cost of $170,000 per tower, and another 3,000 highly rural cells are built by 2021 at twice that cost (see CBO Score, pp. 7 - 8).
[3]: [1] * [2] / 1,000,000.
[4] & [5]: According to the S.911 Score $11500 million is spent on capital expenditure. Given that tower costs total $8670 million, fixed costs must be the remaining $2830 million. This represents 25% of capital expenditure.
[6]: 18% * cumulative([5]); based on The Brattle Group analysis of the FCC Cost Model, operating costs are equal to 18% of cumulative capital expenditure.
[7]: Cumulative([1]) / sum([1]).
[8]: Brattle assumptions to achieve a total net income of approximately -$1000 million for the period 2012 - 2021.
[9]: [8] * $100 per Public Safety subscriber * 1.7 million Public Safety subscribers. According to the BLS there were approximately 1.5 million employed firefighters (excludes volunteers), EMT and paramedics and police officers in the U.S. in 2008. By 2018, there are projected to be over 1.6 million employed Public Safety personnel, which implies a 1.08% annual increase in personnel. Projecting this annual increase out three more years, by 2021 there should be 1.7 million Public Safety employees."
[9]: [8] * $ per Public Safety subscriber * 1.5 million Public Safety subscribers. According to the BLS there were approximately 1.5 million employed firefighters (excludes volunteers), EMT and paramedics and police officers in the U.S. in
[10]: Lease revenue in 2012 assumed to still be $0; lease revenue in 2013 calculated to achieve approximately -$227 million in net operating income; lease revenue for all subsequent years based on percent increase in leasable capacity in column [8].
[11]: [10] * (1 + 19%); due to 19% increase in capacity with the additional A Block spectrum.
[12]: [11] - [6] - [9].
[13]: See S.911 Score, pp. 2 - 3.
[14]: [5] - [12] - [13].
[15]: Cumulative([14]) through previous year.
[16]: [15] * 1%; Where interest rate chosen to achieve $250 million in total interest payments based on S.911 Scoring in which the difference between total build-out cost ($11750 million and total capital expenditure $11500 million is $250 million in interest payments.
[17]: [5] + [16].